

AD-R149 084

A METAL-CATALYZED REARRANGEMENT OF ALKENE-ALKYNES AND
THE STEREOCHEMISTRY. (U) COLUMBIA UNIV NEW YORK DEPT OF
CHEMISTRY T J KATZ ET AL. 27 DEC 84 TR-8

1/1

UNCLASSIFIED

N00014-79-C-0603

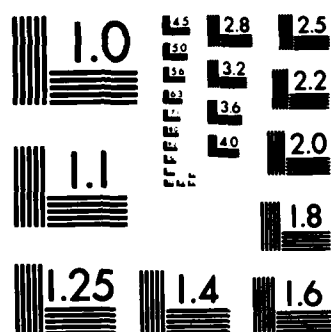
F/G 7/4

NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A149 084

DTIC FILE COPY

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM | | | | | | | | | | | | |
|---|-------------------------|--|---------------|-----------|-----------|-----------|-------------------------|---------------|-------------------|-----------------|------------|----------------|--------------------|--|
| 1. REPORT NUMBER Technical Report No. 8 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER | | | | | | | | | | | | |
| 4. TITLE (and Subtitle) A METAL-CATALYZED REARRANGEMENT OF ALKENE- ALKYNES AND THE STEREOCHEMISTRY OF METALLACYCLO- BUTENE RING OPENING | | 5. TYPE OF REPORT & PERIOD COVERED Technical Report | | | | | | | | | | | | |
| AUTHOR(s) Thomas J. Katz and Timothy M. Sivavec | | 6. PERFORMING ORG. REPORT NUMBER | | | | | | | | | | | | |
| PERFORMING ORGANIZATION NAME AND ADDRESS Thomas J. Katz Columbia University Chemistry Department New York, NY 10027 | | 8. CONTRACT OR GRANT NUMBER(s) N00014-79-C-0683 | | | | | | | | | | | | |
| CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research - Chemistry Arlington, VA 22217 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR 356-726 | | | | | | | | | | | | |
| 12. REPORT DATE December 27, 1984 | | 13. NUMBER OF PAGES 14 | | | | | | | | | | | | |
| 15. SECURITY CLASS. (of this report) | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE | | | | | | | | | | | | |
| 16. DISTRIBUTION STATEMENT (of this Report) This document has been approved for public release and sale; its distribution is unlimited. | | | | | | | | | | | | | | |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) JAN 9 1985 | | | | | | | | | | | | | | |
| 18. SUPPLEMENTARY NOTES To be published in the <u>Journal of the American Chemical Society</u> | | | | | | | | | | | | | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <table border="0"> <tr> <td>Polyacetylene</td> <td>Mechanism</td> <td>Catalysis</td> </tr> <tr> <td>Acetylene</td> <td>Molecular Rearrangement</td> <td>Metal-carbene</td> </tr> <tr> <td>Olefin Metathesis</td> <td>Stereochemistry</td> <td>Initiation</td> </tr> <tr> <td>Polymerization</td> <td>Metallacyclobutene</td> <td></td> </tr> </table> | | | Polyacetylene | Mechanism | Catalysis | Acetylene | Molecular Rearrangement | Metal-carbene | Olefin Metathesis | Stereochemistry | Initiation | Polymerization | Metallacyclobutene | |
| Polyacetylene | Mechanism | Catalysis | | | | | | | | | | | | |
| Acetylene | Molecular Rearrangement | Metal-carbene | | | | | | | | | | | | |
| Olefin Metathesis | Stereochemistry | Initiation | | | | | | | | | | | | |
| Polymerization | Metallacyclobutene | | | | | | | | | | | | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A molecular rearrangement is described that demonstrates how alkyl-metal-carbenes are generated when metal derivatives combine with acetylenes and olefins and shows that tungsten-carbenes not stabilized by heteroatoms insert into acetylenes. It reveals that this insertion can be remarkably stereo-selective. With catalytic amounts of carbene-tungsten carbonyls, biphenyls substituted at the 2 and 2' positions by vinyl and acetylene groups yield isomeric 9-vinylphenanthrenes. With stoichiometric amounts, they yield 9-vinylphenanthrenes whose structures contain the carbene moiety of the metal-carbene. | | | | | | | | | | | | | | |

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

OFFICE OF NAVAL RESEARCH

Contract N00014-79-C-0683

Task No. NR 356-726

TECHNICAL REPORT NO. 8

A Metal-Catalyzed Rearrangement of Alkene-Alkynes
and the Stereochemistry of Metallacyclobutene Ring Opening

by

Thomas J. Katz and Timothy M. Sivavec

Prepared for Publication

in the

Journal of the American Chemical Society

Columbia University
Department of Chemistry
New York, New York

December 27, 1984

A-1

Reproduction in whole or in part is permitted for
any purpose of the United States Government



This document has been approved for public release
and sale; its distribution is unlimited

84 12 31 066

A Metal-Catalyzed Rearrangement of Alkene-Alkynes
and the Stereochemistry of Metallacyclobutene Ring Opening

Thomas J. Katz^{*} and Timothy M. Sivavec

Department of Chemistry

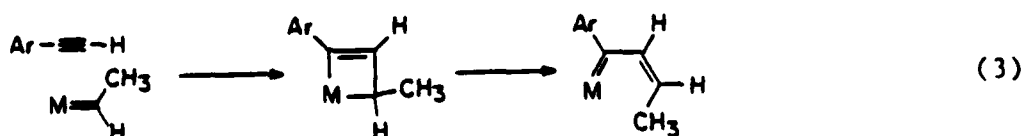
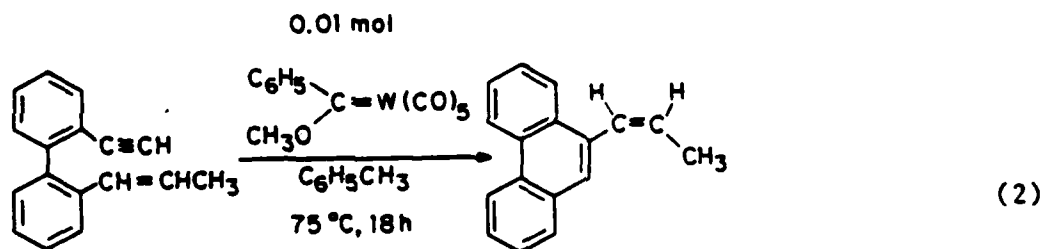
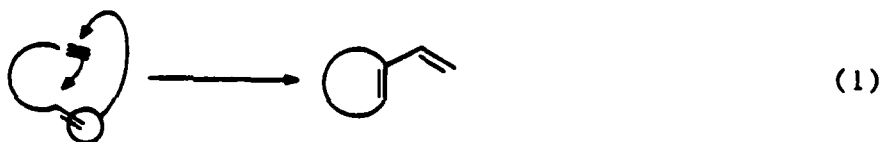
Columbia University

New York, New York 10027

Abstract. A new molecular rearrangement is described that demonstrates how alkyl-metal-carbenes are generated when metal derivatives (here stabilized carbene-tungsten carbonyls) combine with acetylenes and olefins and shows that tungsten-carbenes not stabilized by heteroatoms insert into acetylenes. It reveals that this insertion can be remarkably stereoselective.

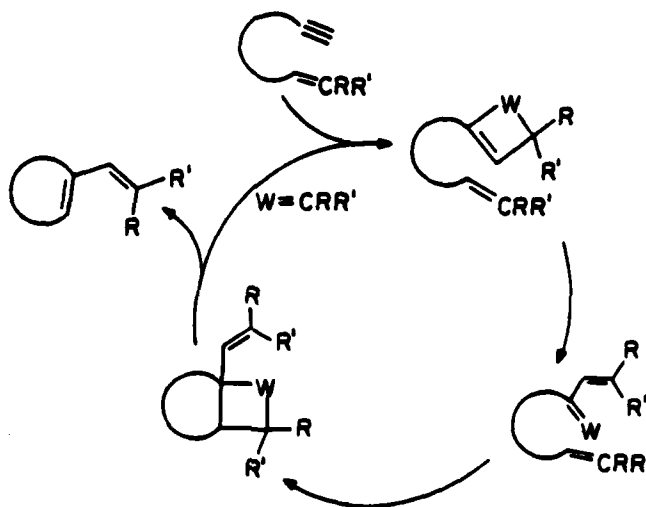
With catalytic amounts of carbene-tungsten carbonyls, biphenyls substituted at the 2 and 2' positions by vinyl and acetylene groups yield isomeric 9-vinylphenanthrenes. With stoichiometric amounts, they yield 9-vinylphenanthrenes whose structures contain the carbene moiety of the metal-carbene.

We are reporting a new molecular rearrangement, outlined in general form as equation 1 and illustrated by a specific example in equation 2, a hybrid of the metal-catalyzed acetylene polymerization¹ and olefin metathesis² reactions. It demonstrates how alkyl-metal-carbenes are generated when metal derivatives (here stabilized carbene-tungsten carbonyls)³ combine with acetylenes and olefins,^{1d,4,5} and it shows that tungsten-carbenes not stabilized by heteroatoms insert into acetylenes, the essential postulate underlying the proposition that the acetylene polymerization is an olefin metathesis.^{1b-d,4,5} It reveals that this insertion can be remarkably stereoselective in the sense indicated in equation 3.⁶



The rearrangement is presumed to follow the pathways in Scheme I after an initiation involving similar steps, summarized as equation 4.¹¹ Table I

Scheme I



records the yields obtained (and where relevant the stereochemistries) with various molecules 1^{21,29} and initiators 2. That equation 4 does accurately depict the initiation, and consequently that Scheme I probably does indicate how the reaction works, is demonstrated by the experiments summarized in

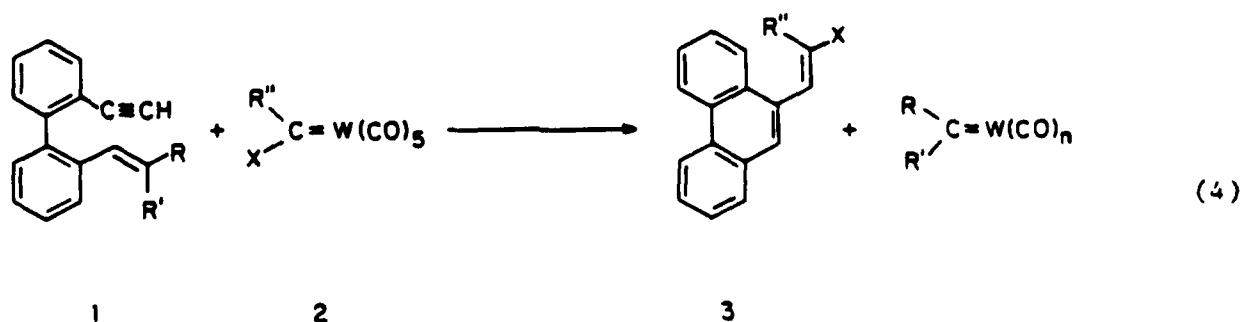


Table II, which show that examples of molecules 1 combine with stoichiometric amounts of metal-carbenes 2 to give the products 3 of equation 4.

The experiments define for the first time what the stereochemistry is of the pericyclic transformation of a metallacyclobutene to a metallabutadiene when there are no stabilizing heteroatoms.⁶ This stereochemistry should be embodied in the structures of acetylene polymers formed by metathesis reactions, but except for that of polyacetylene itself,³⁸ whose formation may not involve the steps in equation 3,³⁹ the structures of these polymers have not been positively defined.⁴⁰ The high stereoselectivity recorded in Table I [95 % at 50 °C when the initiator is pentacarbonyl(diphenylmethylene)tungsten] implies that when the cyclobutene in equation 3 opens, the methyl prefers to rotate toward the metal. Possibly its C-H is attracted to the coordinatively unsaturated center.⁴⁴

Acknowledgment. We are grateful to the National Science Foundation (grant CHE 81-08998) and the U.S. Navy, Office of Naval Research, for supporting this work.

References and Notes

- (1) (a) Simionescu, C. I.; Percec, V. Prog. Polym. Sci. 1982, 8, 133.
(b) Masuda, T.; Higashimura, T. Acc. Chem. Res. 1984, 17, 51. (c) Katz, T. J.; Lee, S. J. J. Am. Chem. Soc. 1980, 102, 422. (d) Katz, T. J.; Lee, S. J.; Shippey, M. A. J. Mol. Cat. 1980, 219. (e) Chauser, M. G.; Rodionov, Yu. M.; Misin, V. M.; Cherkashin, M. I. Russ. Chem. Rev. 1976, 45, 348.
- (2) (a) Grubbs, R. H. In "Comprehensive Organometallic Chemistry"; Wilkinson, G., Ed.; Pergamon Press: Oxford, 1982; Vol. 8, p. 499. (b) Ivin, K. J. "Olefin Metathesis"; Academic Press: London, 1983.
- (3) Fischer, H. in "The Chemistry of the Metal-Carbon Bond," Hartley, F. R. and Patai, S., Eds.; Wiley: New York, 1982; Vol. 1, pp. 181-231.
- (4) (a) Katz, T. J.; Lee, S. J.; Nair, M.; Savage, E. B. J. Am. Chem. Soc. 1980, 102, 7940. (b) Katz, T. J.; Han, C-C. Organometallics 1982, 1, 1093.
- (5) (a) Katz, T. J.; Savage, E. B.; Lee, S. J.; Nair, M. J. Am. Chem. Soc. 1980, 102, 7942. (b) Han, C-C.; Katz, T. J. J. Am. Chem. Soc., submitted for publication.
- (6) Pentacarbonylchromium- and tungsten-carbenes carrying as stabilizers on the carbene carbon an alkoxyl or two aryls insert into ynamines much as in equation 3⁷ (the stereochemistry of some of these insertions have been analyzed⁸) and react with carbon-substituted alkynes to give phenols, indenenes, furans, and cyclobutenones.^{7,9} The only metal-monoalkylcarbene to have been added to an acetylene is a tantalum neopentylidene, but the stereochemistry of the single reported adduct is unknown.¹⁰
- (7) Dötz, K. H. Pure Appl. Chem. 1983, 55, 1689.

(8) (a) Dötz, K. H. Chem. Ber. 1977, 110, 78. (b) Dötz, K. H.; Pruskil, I. ibid. 1978, 111, 2059.

(9) Foley, H. C.; Strubinger, L. M.; Targos, T. S.; Geoffroy, G. L. J. Am. Chem. Soc. 1983, 105, 3064.

(10) Wood, C. D.; McLain, S. J.; Schrock, R. R. J. Am. Chem. Soc. 1979, 101, 3210.

(11) This formulation derives from previous studies showing that metal-carbenes induce acetylenes to polymerize,^{1c} that acetylenes induce metal derivatives, including metal-carbenes, to metathesize olefins,⁴ that stabilized metal-carbenes add faster to acetylenes than to olefins,⁵ that the carbons of metal-carbenes bond preferentially to the less substituted ends of acetylenes¹² (as also olefins¹³), and that olefinic metal-carbenes give cycloolefins.^{14,15} An alternative is possible, in which after the initiation external metal carbenes attack the olefin and internal metal carbenes attack the acetylene, but the regiospecificity of the first of these steps would be peculiar for the substrate 1, $R = R' = CH_3$.¹⁷

(12) Wulff, W. D.; Tang, P.-C.; McCallum, J. S. J. Am. Chem. Soc. 1981, 103, 7677.

(13) (a) McGinnis, J.; Katz, T. J.; Hurwitz, S. J. Am. Chem. Soc. 1976, 98, 2605. (b) Katz, T. J. Adv. Organometal. Chem. 1977, 16, 283. (c) Casev, C. P.; Tunistra, H. E.; Saeman, M. J. Am. Chem. Soc. 1976, 98, 608.

(14) (a) Reference 2b, Chapter 11. (b) Katz, T. J.; Rothchild, R. J. Am. Chem. Soc. 1976, 98, 2519. (c) Grubbs, R. H.; Carr, D. D.; Hoppin, C.; Burk, P. L. ibid. 1976, 98, 3478.

(15) Related metal-carbenes that are stabilized by heteroatoms chelate to pendant olefins and yield cyclopropanes.¹⁶

(16) (a) Casey, C. P.; Vollendorf, N. W.; Haller, K. J. J. Am. Chem. Soc. 1984, 106, 3754. (b) Casey, C. P.; Shusterman, A. J.; Vollendorf, N. W.; Haller, K. J. ibid. 1982, 104, 2417. (c) Casey, C. P.; Shusterman, A. J. J. Mol. Catal. 1980, 8, 1. (d) Toledano, C. A.; Rudler, H.; Daran, J-C.; Jeannin, Y. J. Chem. Soc., Chem. Commun., 1984, 574. (e) Toledano, C. A.; Levisalles, J.; Rudler, M.; Rudler, H.; Daran, J-C.; Jeannin, Y. J. Organomet. Chem. 1982, 228, C7.

(17) The translationally invariant structures of the polymers of 1-methylcyclobutene¹⁸ and trans-1-methyl-cyclooctene¹⁹ and the specific union of the less-substituted with the more-substituted moieties when 2-methyl-1-pentene metathesizes with 2-methyl-2-butene²⁰ imply that the carbon end of a metal-carbene (disubstituted, not monosubstituted as in the alternative considered here) bonds preferentially to the less-substituted end of a trisubstituted double bond.

(18) Katz, T. J.; McGinnis, J.; Altus, C. J. Am. Chem. Soc. 1976, 98, 606.

(19) Lee, S. J.; McGinnis, J.; Katz, T. J. J. Am. Chem. Soc. 1976, 98, 7818.

(20) McGinnis, J., Dissertation, Columbia University, New York, NY, 1976, p. 78.

(21) Enynes 1 were prepared from $(C_6H_5)_3PCHRR'^+ Br^- / NaNH_2$ ²³ and monoacetals made from [1,1'-biphenyl]-2,2'-dicarboxaldehyde²⁴ and 0.8 equiv ethylene glycol or 2,2-dimethyl-1,3-propanediol (p-TsOH, C_6H_6). Hydrolysis (5% aq HCl/THF) and then $LiCl_2CPO(OEt)_2 / n-BuLi$ ²⁵ (2.2 equiv) or $((C_6H_5)_3PCH_2Br)^+ Br^- / t-BuOK$ ²⁶ (2 equiv) gave 1.

(22) Authentic samples were prepared from phenanthrene-9-carboxaldehyde.^{23,27} The 9-(1-propenyl)phenanthrenes were 86 % one isomer, presumably cis.²³ The olefin-olefin proton couplings (cis, $J = 11.2$ Hz, and trans, $J = 15.4$ Hz) support this assignment.²⁸

(23) Schlosser, M.; Schaub, B. Chimia 1982, 36, 396.

(24) Bailey, P. S.; Erikson, R. E. "Organic Syntheses"; Wiley: New York, 1973; Collect. Vol. V, p. 489.

(25) Villieras, J.; Perriot, P.; Normant, J. F. Synthesis 1975, 458.

(26) Matsumoto, M.; Kuroda, K. Tetrahedron Lett. 1980, 4021.

(27) The ^1H NMR spectra of 9-(2-methyl-1-propenyl)phenanthrene, 9-ethenylphenanthrene, and trans-9-(1-propenyl)phenanthrene match those published: Matsumoto, M.; Dobashi, S.; Kondo, K. Bull. Chem. Soc. Jpn. 1978, 51, 185.

(28) Jackman, L. M.; Sternhell, S. "Applications of NMR Spectroscopy in Organic Chemistry," 2nd ed.; Pergamon Press: Oxford, 1969, pp. 301-302.

(29) The aliphatic enynes 7-nonen-1-yne and 6-octen-1-yne when combined with 0.01 equiv $(\text{CO})_5\text{W}=\text{C}(\text{C}_6\text{H}_5)(\text{OCH}_3)$ under similar conditions and at even higher dilution (1.2×10^{-3} M) gave no vinyl cyclohexene (GLC comparison), but > 90 % yield of oligomers including benzenoid trimers (δ 6.80). No high molecular weight polymers were recognized by gel-permeation chromatography.

(30) When $\text{R}'' = \text{C}_6\text{H}_5$, the crude reaction mixture (^1H NMR analysis) contained the enol ethers (1.0 : 1.8 mixture of E : Z)³² and only traces of the ketone 9-phenanthryl- $\text{CH}_2\text{COC}_6\text{H}_5$ (δ 4.78).³¹ When $\text{R}'' = \text{CH}_3$ it contained the corresponding ketone [δ 2.14 (s, 2 H), 4.15 (s, 2 H), 4.15 (s, 2 H), 7.6 - 8.8 (m, 9 H)] and no enol ether.³²

(31) The ^1H NMR spectrum (CDCl_3) of the Z-isomer³² includes δ 3.58 (s, 3 H), 6.74 (s, 1 H), 6.8 - 8.8 (m, 14 H). Resonances exhibited by the mixture at 3.99 (s, 3 H), 6.22 (s, 1 H), 6.8 - 8.8 (m, 14 H) are assigned to the E-isomer.

(32) Authentic samples of 9-vinylphenanthrenes 3 were prepared as follows: 3 ($\text{R}'' = \text{CH}_3$, $\text{X} = \text{OCH}_3$) from phenanthrene-9-carboxaldehyde and $(\text{C}_6\text{H}_5)_3\text{P}^+\text{CHCH}_3(\text{OCH}_3)\text{Cl}^-/\text{t-BuOK}$ ³³; Z-3 ($\text{R}'' = \text{C}_6\text{H}_5$, $\text{X} = \text{OCH}_3$) from 9-bromophenanthrene and n-BuLi, then styrene oxide³⁴, oxidation with $\text{Pyr} \cdot \text{HCl} \cdot \text{CrO}_3$,³⁵ and stereospecific O-methylation using t-BuOK/HMPA/dimethyl sulfate;³⁶ 3 ($\text{R}'' = \text{X} = \text{C}_6\text{H}_5$) from phenanthrene-9-carboxaldehyde and $(\text{C}_6\text{H}_5)_3\text{PCH}(\text{C}_6\text{H}_5)_2\text{Br}^{-37}/\text{NaNH}_2$. All were characterized satisfactorily by ^1H NMR.

(33) Coulson, D. R. Tetrahedron Lett. 1964, 3323.

(34) Cristol, S. J.; Douglass, J. R.; Meek, J. S. J. Am. Chem. Soc. 1951, 73, 816.

(35) Corey, E. J.; Suggs, J. W. Tetrahedron Lett. 1975, 2647.

(36) Krow, G. R.; Michener, E. Synthesis 1974, 572.

(37) Horner, L.; Lingnau, E. Justus Liebigs Ann. Chem. 1955, 591, 135.

(38) (a) Shirakawa, H.; Ikeda, S. Polym. J. 1971, 2, 231.

(b) Shirakawa, H.; Ito, T.; Ikeda, S. ibid. 1973, 4, 460. (c) Maricq, M. M.; Waugh, J. S.; MacDiarmid, A. G.; Shirakawa, H.; Heeger, A. J. J. Am. Chem. Soc. 1978, 100, 7729. (d) Bernier, P.; Schue, F.; Sledz, J.; Rolland, M.; Giral, L. Chem. Scr. 1981, 17, 151.

(39) Clarke, T. C.; Yannoni, C. S.; Katz, T. J. J. Am. Chem. Soc. 1983, 105, 7787.

(40) IR^{41} and ^1H NMR^{41a,42} spectra have been used to assign stereochemistries to poly(phenylacetylene)s and ^{13}C NMR spectra to

poly(t-butylacetylene)s,⁴³ but the basis for the assignments is not rigorous.

(41) (a) Simionescu, C. I.; Percec, V.; Dumitrescu, S. J. Polym. Sci., Polym. Chem. Ed. 1977, 15, 2497. (b) Masuda, T.; Sasaki, N.; Higashimura, T. Macromolecules 1975, 8, 717.

(42) (a) Simionescu, C. I.; Percec, V. J. J. Polym. Sci., Polym. Lett. Ed. 1979, 17, 421. (b) Simionescu, C. I.; Percec, V. J. Polym. Sci., Polym. Chem. Ed. 1980, 18, 147.

(43) (a) Masuda, T.; Okano, Y.; Kuwane, Y.; Higashimura, T. Polym. J. 1980, 12, 907. (b) Okano, Y.; Masuda, T.; Higashimura, T. Polym. J. 1982, 14, 477.

(44) Brookhart, M.; Green, M. L. H. J. Organomet. Chem. 1983, 250, 395.

Table I. Yields and Stereochemistries of 9-Vinylphenanthrenes Obtained According to Equation 1 from Enynes 1²¹ and Catalytic Amounts of Metal-Carbenes 2 in which R'' = C₆H₅.^a

| <u>1</u> | | X | yield | product |
|----------------------------------|---------------------|-------------------------------|------------------|---------------------------|
| R | R' | in <u>2</u> | (%) ^b | % <u>cis</u> ^c |
| H | H | OCH ₃ | 31 | |
| H | H | C ₆ H ₅ | 18 | |
| CH ₃ (H) ^d | H(CH ₃) | OCH ₃ | 26 | 78 |
| CH ₃ (H) | H(CH ₃) | C ₆ H ₅ | 19 | 95 |
| CH ₃ | CH ₃ | OCH ₃ | 24 | |
| CH ₃ | CH ₃ | C ₆ H ₅ | 24 | |

^aEnynes 1 (1 equiv) and n-nonane (0.5 - 1.0 equiv, internal standard for GLC analysis) were diluted to 0.10 M with toluene, added to metal-carbenes 2 (0.01 equiv), degassed, and sealed in a vacuum. When X was OCH₃, reactions were run for 18 h at 75 °C, and when C₆H₅, for 16 h at 50 °C. The products were identified by comparing GLC retention times (30 m x 0.316 mm capillary column coated with 0.25 μm Carbowax 20 M) and ¹H NMR spectra with those of authentic samples (see note 22). ^bYields were determined by GLC. ^cStereochemistries were analyzed by ¹H NMR [CH₃ resonances in 9-(1-propenyl)phenanthrene (see note 22) in CDCl₃: cis, δ 1.83 (dd, 7.0 and 1.8 Hz); trans, δ 2.04 (dd, 6.6 and 1.7 Hz)]. ^dInitially 56 % cis.

Table II. Yields of 9-Vinylphenanthrenes 3 from Reactions of Molecules 1 with Stoichiometric Amounts of Metal-Carbenes 2 (Equation 4).^a

| <u>1</u> | | <u>2</u> | | yield |
|----------------------------------|---------------------|-------------------------------|-------------------------------|------------------|
| R | R' | R'' | X | (%) ^b |
| H | H | C ₆ H ₅ | OCH ₃ | 50 |
| H | H | CH ₃ | OCH ₃ | 42 |
| H | H | C ₆ H ₅ | C ₆ H ₅ | 51 |
| CH ₃ (H) ^c | H(CH ₃) | C ₆ H ₅ | OCH ₃ | 41 |
| CH ₃ (H) | H(CH ₃) | CH ₃ | OCH ₃ | 40 |
| CH ₃ (H) | H(CH ₃) | C ₆ H ₅ | C ₆ H ₅ | 40 |

^aDegassed 0.05 M solutions of 1 (1 equiv) and metal-carbenes 2 (1 equiv) in toluene were heated in an evacuated ampoule. When X was C₆H₅, reactions were run at 50 °C for 16 h, and when OCH₃, at 75 °C for 24 h, except that for the next-to-last entry the time was 18 h. Evaporation of solvent and chromatography on Florisil with pentane-methylene chloride gave 3 when R'' = X = C₆H₅, and the ketones 9-phenanthryl-CH₂COR'' corresponding to enol ethers 3 when R'' = C₆H₅ or CH₃ and X = OCH₃ (see note 30). Products were identified by comparing ¹H NMR spectra with those of authentic samples (see note 32). ^bYields of isolated products.

^cInitially 56 % cis.

TECHNICAL REPORT DISTRIBUTION LIST, GEN

| | <u>No. Copies</u> | | <u>No. Copies</u> |
|--|-----------------------|--|-----------------------|
| Office of Naval Research Attn: Code 413 800 N. Quincy Street Arlington, Virginia 22217 | 2 | Dr. David Young Code 334 NORDA NSTL, Mississippi 39529 | 1 |
| Dr. Bernard Douda Naval Weapons Support Center Code 5042 Crane, Indiana 47522 | 1 | Naval Weapons Center Attn: Dr. A. B. Amster Chemistry Division China Lake, California 93555 | 1 |
| Commander, Naval Air Systems Command Attn: Code 310C (H. Rosenwasser) Washington, D.C. 20360 | 1 | Scientific Advisor Commandant of the Marine Corps Code RD-1 Washington, D.C. 20380 | 1 |
| Naval Civil Engineering Laboratory Attn: Dr. R. W. Drisko Port Hueneme, California 93401 | 1 | U.S. Army Research Office Attn: CRD-AA-IP P.O. Box 12211 Research Triangle Park, NC 27709 | 1 |
| Defense Technical Information Center Building 5, Cameron Station Alexandria, Virginia 22314 | 12 | Mr. John Boyle Materials Branch Naval Ship Engineering Center Philadelphia, Pennsylvania 19112 | 1 |
| DTNSRDC Attn: Dr. G. Bosmajian Applied Chemistry Division Annapolis, Maryland 21401 | 1 | Naval Ocean Systems Center Attn: Dr. S. Yamamoto Marine Sciences Division San Diego, California 91232 | 1 |
| Dr. William Tolles Superintendent Chemistry Division, Code 6100 Naval Research Laboratory Washington, D.C. 20375 | 1 | | |

ABSTRACTS DISTRIBUTION LIST, 356B

Professor A. G. MacDiarmid
Department of Chemistry
University of Pennsylvania
Philadelphia, Pennsylvania 19174

Dr. E. Fischer, Code 2853
Naval Ship Research and
Development Center
Annapolis, Maryland 21402

Professor H. Allcock
Department of Chemistry
Pennsylvania State University
University Park, Pennsylvania 16802

Professor R. Lenz
Department of Chemistry
University of Massachusetts
Amherst, Massachusetts 01002

Professor M. David Curtis
Department of Chemistry
University of Michigan
Ann Arbor, Michigan 48105

Dr. J. Griffith
Naval Research Laboratory
Chemistry Section, Code 6120
Washington, D.C. 20375

Professor G. Wnek
Department of Materials Science
and Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Mr. Samson Jennekke
Honeywell Corporate Technology Center
10701 Lyndale Avenue South
Bloomington, Minnesota 55420

Dr. Richard M. Laine
SRI International
333 Ravenswood Avenue
Menlo Park, California 94025

Dr. James McGrath
Department of Chemistry
Virginia Polytechnic Institute
Blacksburg, Virginia 24061

Dr. Adolf Amster
Chemistry Division
Naval Weapons Center
China Lake, California 93555

Professor C. Allen
Department of Chemistry
University of Vermont
Burlington, Vermont 05401

Dr. William Tolles
Code 6100
Naval Research Laboratory
Washington, D.C. 20375

Professor T. Katz
Department of Chemistry
Columbia University
New York, New York 10027

Professor J. Salamone
Department of Chemistry
University of Lowell
Lowell, Massachusetts 01854

Professor J. Chien
Department of Chemistry
University of Massachusetts
Amherst, Massachusetts 01854

Professor William R. Krigbaum
Department of Chemistry
Duke University
Durham, North Carolina 27706

Dr. R. Miller
IBM Research Laboratory K42/282
5600 Cottle Road
San Jose, California 95193

ABSTRACTS DISTRIBUTION LIST, 356B

Professor T. Marks
Department of Chemistry
Northwestern University
Evanston, Illinois 60201

Professor Malcolm B. Polk
Department of Chemistry
Atlanta University
Atlanta, Georgia 30314

Dr. Kurt Baum
Fluorochem, Inc.
680 S. Ayon Avenue
Azusa, California 91702

Professor H. Ishida
Department of Macromolecular Science
Case Western University
Cleveland, Ohio 44106

Professor Stephen Wellinghoff
Department of Chemical Engineering
University of Minnesota
Minneapolis, Minnesota 55455

Professor G. Whitesides
Department of Chemistry
Harvard University
Cambridge, Massachusetts 02138

Dr. K. Paciorek
Ultrasystems, Inc.
P.O. Box 19605
Irvine, California 92715

Professor H. Hall
Department of Chemistry
University of Arizona
Tucson, Arizona 85721

Professor D. Seyferth
Department of Chemistry
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

END

FILMED

2-85

DTIC